Title: Temperature/Distance Lab

Brief Overview:

Students will use the CBL with a temperature probe to measure the air temperature at various distances from a heat source. They will record the data and enter it into the statistical lists on the TI-82, then observe the graph. They will then use the TI-82 to do a regression, getting the "best-fitting curve".

Link to Standards:

- **Problem Solving** Students will investigate the effect of a heat source on air temperature and make predictions based on their observations.

- **Communication** Students will work cooperatively to develop a generalization of their investigation and express their findings in writing.

- **Reasoning** Students will establish conclusions based on the collected data.

- **Functions** Students will represent and analyze a relationship using tables, rules, equations, and graphs.

- **Statistics** Students will express data in scatter plot form and determine a function of best fit.

Grade/Level:

Algebra II or higher

Duration/Length:

90 minutes

Prerequisite Knowledge:

Students should be able to do the following:

- Identify and graph a simple power function
- Enter data into the statistical lists on the TI-82
- Graph a scatter plot on the TI-82
- Use the TI-82 to perform a regression to fit the data, obtaining a function
- Copy that function into the "y = " list in order to graph it

Objectives:

Students will :

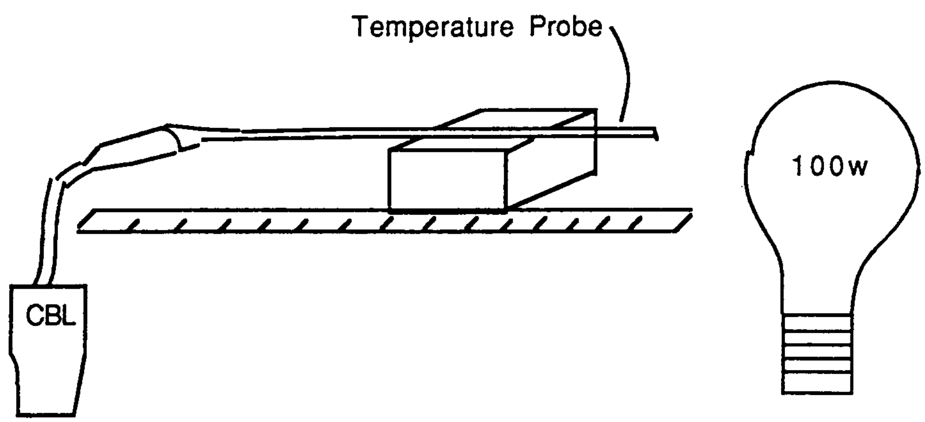
- work cooperatively in groups.
- collect data, using the CBL with its temperature probe; enter it into a list on the TI-82 calculator.
- graph a scatter plot of the data, temperature vs. distance.
- find the "best-fitting" curve, using the regression feature on the TI-82.
- make predictions, based on previous results.

Materials/Resources/Printed Materials:

- 100 watt incandescent light bulb with socket
- CBL with temperature probe
- meter stick
- TI-82 calculator
- straw or popsicle stick
- rubber band
- watch or timing device

Development/Procedures:

- Note that the procedure below is a suggested one; it can be modified in any way that permits you to accomplish the goal of obtaining temperature readings at fairly precise distances from a steady heat source (in this case, a light bulb).
- Students will work in groups of 2,3, or 4, using roles of positioner, timer, temperature-watcher, and recorder. The following tasks must be performed during each experiment:
  Move the temperature probe into position (this person is the group leader).
  Keep track of the time.
  Watch the CBL temperature readings.
  Record the highest temperature obtained during the designated time in each position.
- Turn on the bulb.
- Each student records predictions for the relationship between air temperature and distance from the heat source(the bulb) on the worksheet and sketches the corresponding scatter plot.
- Place the meter stick on a horizontal surface, with the end directly below the end of the bulb.
- Using one or more rubber bands, a straw or popsicle stick, and a small box, position the temperature probe, the meter stick, and the light bulb as shown below.



- Use the CBL with its temperature probe to obtain the air temperature readings at the indicated distances, as follows:
  Begin farthest away from the bulb.
  Allow the probe to remain in position for 30 seconds; use the highest reading registered during that time.
  Be sure that the probe remains in a direct horizontal line with the center of the bulb as the readings are obtained; use the rubber band to attach the probe wire to something to elevate it as needed.
- Record the readings on the worksheet; let the next group use the station.
- Enter the readings into the lists on the TI-82.

Evaluation:

Students' worksheets will be collected and graded. A power function is expected to be the result, with an r-value fairly close to -1.

Extension/Follow Up:

- The members of the group interchange roles (i.e. positioner, timer, temperature watcher, recorder), and repeat the experiment; is the data very nearly the same?
  Was the experiment valid?
- Perform the experiment, with the following variations:
  Use a bulb with a different watt rating, or a different (steady) heat source.
  Use a fluorescent bulb with the same watt rating as the incandescent bulb.
  Use a lamp with (or without) a reflector.
- Perform the experiment, measuring light intensity instead of temperature.
- Repeat the experiment, using 60 second time intervals instead of 30 second time intervals; compare the two sets of data.

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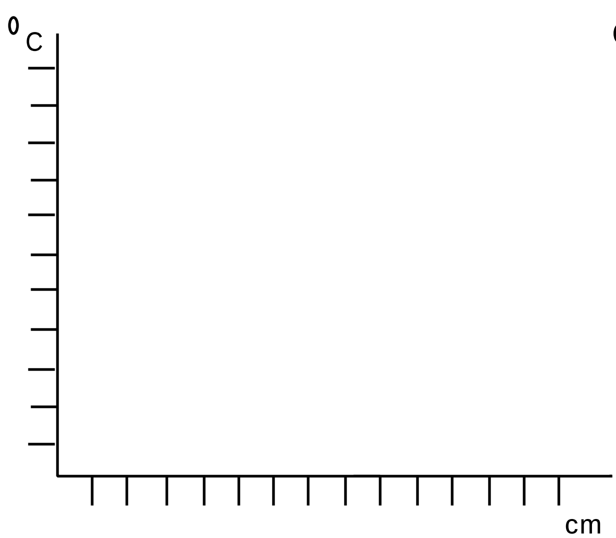
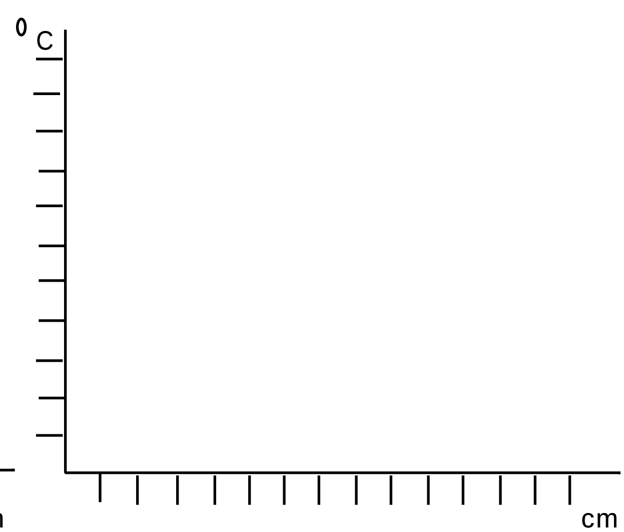
Temperature/Distance Lab Worksheet

Group Name:
Group Leader (Positioner):
Timer:
Temperature Watcher:
Recorder:
Heat Source (if it is a light bulb, specify incandescent or fluorescent, and how many watts):

Predicted Temperatures		Measured Temperatures	
Distance from Heat Source (cm.)	Air Temperature	Distance from Heat Source (cm.)	Air Temperature
20		20	
15		15	
10		10	
8		8	
6		6	
4		4	
2		2	
1		1	
.5		.5	





Follow-up Questions

1. Were your predicted values close to the actual measured values? (There is no "correct" answer here). Which member of your group had the best predictions?

2. Is the relationship between temperature and distance an inverse one?

3. Explain why your graph has the shape it has.

4. Write the function which you found to be the best-fit for your data:

   y =

5. What type of function is it (linear, exponential, quadratic, some other power function, etc.) ?

6. Write the correlation coefficient:

   r =

   Given that r will have some value between -1 and 1 inclusive, with values of -1 and 1 representing perfect fits, did you get a good fit?

7. How do you think the results would change if the experiment was repeated, with these changes:

   a. reduce the bulb wattage

   b. increase the bulb wattage

   c. use a reflector around the bulb

   d. use a fluorescent bulb instead of an incandescent bulb

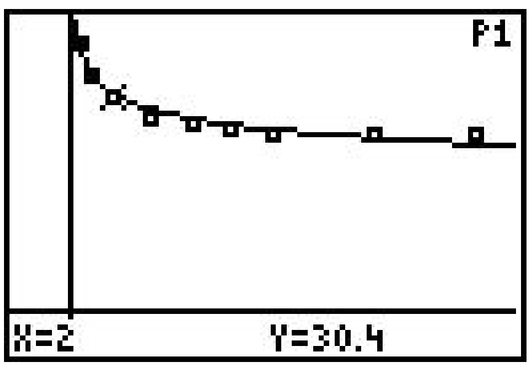
   e. use 60 seconds instead of 30 seconds

Teacher Resource

The following is the result of one experiment:

Distances were entered into list L_1, and temperatures were entered into list L_2. The table is done in the STAT mode on the TI-82. The graph is the result of the scatter plot overlaid with the graph of the function given. This function is the result of the regression analysis.

L_1	L_2
20	25.3
15	25.5
10	25.7
8	26.1
6	26.9
4	27.8
2	30.4
1	33.8
0.5	38.4



PwrReg
$y = a*x$ ^b
$a = 33.81808283$
$b = -.1139131612$
$r = -.9731205825$

$y_1 = 33.818082828245\ X$ ^ $-.1139131612021$

EXTENSION : Introduction into Negative Exponents

This is a discussion which may be used as a segue into an introduction of negative exponents. The discussion may take place immediately following the lab or as a warm up the following class. The students will need the TI - 82 an may use the accompanying worksheet.

"What kind of regression was used to get the equation for your data from the temperature/distance lab?"

power

"What other kind of graphs look like these?"

quadratic

"What is the general form of a quadratic equation ?"

$y = x^2$ *or* $y = ax^2 + bx + c$

"Punch in the equation $y_1 = x^2$ on your graphic calculator in the $\boxed{y =}$ window. Now hit $\boxed{\text{zoom}}$ 6 for a more clear picture. Is the graph from the lab the same as the graph of the quadratic? How are they different?"

no. the quadratic crosses the y-axis. the lab graph does not 'rise' on both sides

"How is the equation $y = x^2$ different from the equation produced in the temperature/distance lab?"

it has a negative exponent

"So let's look at an equation with a negative exponent. Punch in $y_2 = x^{-1}$. I want us to be able to look at some points on the graph and to do that let's use $\boxed{\text{zoom}}$ 4."

"Now hit $\boxed{\text{trace}}$ and go to the quadratic equation where x = 0.What is the value of y?"

y = 0

"Use the arrow keys to locate the point where the graphs intersect. What is that point?"

(1,1)

"Continue to move the cursor to tell me what happens to y as x increases."

y increases

"Hit the up arrow key to move the cursor to the other graph. What is the value of y when x = 0? Why?"

there is no value. the graph never touches the x-axis

"What happens to y as the value of x increases?"

y decreases

Think for a minute: what kind of an expression decreases when you increase part of the expression ; also, for what kind of mathematical expression is there no known value?"

fraction; fraction with a zero in the denominator

"With this in mind, what might be another way to write the expression x^{-1}?"

$x^{-1} = {}^{1}/_{x}$

FOLLOW UP : Temperature/Distance Lab

Use the temperature/distance lab to help answer the following questions.

1. What kind of regression was used in the temperature/distance lab?

2. What type of graph does this look like? Draw an example and label.

Turn on your TI - 82 and push y=. Then punch in $y_1 = x^2$.

3. Does this look like your example in #2?

4. How is this graph different from the temperature/distance lab graph?

5. How do the two equations differ?

6. Let' look at an equation with a negative exponent. Punch in $y_2 = x^{-1}$.Hit zoom 4 then trace. Find the value of y when x = 0.

   y =

7. What happens to the y values on this graph as the x values increase?

Now use the up arrow key to move the cursor to the other graph.
8. What is the value of y when x= 0? Can you explain this?

   y =

9. What happens to the values of y as the x values increase?

10. What kind of expression has its value decrease as one part of the expression increases?

11. Complete the equation:

   $x^{-1} =$